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SEISMOLOGY IN BRITISH COLUMBIA

BY W. G. MILNE

INTENSIVE investigations of earthquakes in any area are often the result of a serious earthquake. In California, following the famous 1906 San Francisco earthquake, the interest in seismological study greatly increased, and it was at this time that the Seismological Society of America was formed. In British Columbia, the 1946 earthquake, although on a much smaller scale, showed the need for further study of the seismicity of the province. Probably as a direct result of this earthquake there is now a network of seismograph stations making it possible to locate most of the frequent small tremors in south-western British Columbia.

Seismological study in British Columbia was officially begun on January 1, 1899, when a Milne seismograph was purchased by the Dominion Government Meterological Service and installed on piers in the basement of the Customs Building near the inner harbour in Victoria. This was the second seismograph in Canada, being preceded by a similar unit in Toronto. The Victoria instrument, number 10 of the series built under Dr. John Milne's guidance for the study of earthquakes, is still in good condition in a museum at the Meteorological Station in Victoria. With the records from this seismograph (paper speed of 2.5 inches per hour, magnification 100), Mr. Baynes Reid, Superintendent of the Victoria Meteorological Office, and his successor, Mr. F. Napier Denison, studied earthquakes occurring at various places on the earth. Mr. Denison has written accounts of these studies in many previous issues of this JOURNAL.

In 1916 a new Meteorological Station was built at Gonzales Heights in Victoria, and the Milne seismograph was moved to a pier in the basement of the office building of the Dominion Astrophysical Observatory,

where it still rests. Mr. Denison built and put into operation at the Gonzales Observatory a similar horizontal-component instrument, and at about the same time added a Wiechert, 80 kgm. vertical-component seismograph. In 1922 two horizontal Milne-Shaw seismographs were located at Gonzales, and with the added sensitivity of these instruments the original Milne became a museum piece. During the period of operation of the Gonzales station several near by earthquakes were recorded. The strongest perhaps is that of December 6, 1918 which had its epicentre off Barkley Sound on the west coast of Vancouver Island. Mr. Denison has described some of the effects of this tremor in the 1919 issue of this JOURNAL.

In 1936 the Seismological Service of Canada was taken over by the Department of Mines and Resources, and henceforth the seismograph records were sent for study to the Dominion Observatory, Ottawa. The seismographs at Victoria however, continued to be operated at the Gonzales Observatory until 1939, when a vault to house the instruments was built at the Dominion Astrophysical Observatory, the instruments being out of operation for a few months during the transfer. The seismographs then came under the care of one of the astronomers, principally Dr. K. O. Wright, and Victoria became one of the stations of the Seismological Service of Canada like Ottawa, Saskatoon, Halifax, Seven Falls, and Shawinigan Falls. During this period the Victoria seismographs were the only instruments operating in British Columbia to record earthquakes. Mr. Denison, during the early 1930's, designed a seismograph similar to the Milne instrument and operated it briefly at Fernie, B.C. to record "bumps" occurring in the coal-mines near by, but no results of this work have been published. The University of Washington seismograph at Seattle has been in operation for many years, and its recordings with those of the United States Coast and Geodetic Survey seismographs at Sitka, Hungry Horse Dam, Butte and Grand Coulee Dam have been of considerable assistance to the Canadian seismologists in supplying information on local shocks.

Instruments

The 1946 earthquake indicated in a very forceful manner the need for better instruments for the study of earthquakes in British Columbia. To understand why, it is necessary to know that during an earthquake the earth usually vibrates at periods ranging from 0.1 second to 20 seconds. Newly-designed instruments indicate that periods as great as a minute or more may exist, but for an ordinary seismograph station it is sufficient to have instruments which will record waves with periods

of 20 seconds. For local earthquakes (a local earthquake being by definition one within 1000 kilometres of a seismograph station), the periods of the waves range from 0.1 to 1.0 second. It is the surface waves from very distant earthquakes that have the very long periods, or to express it in the usual way, the wave periods recorded increase with distance from the epicentre of the earthquake.

At the time of the 1946 earthquake the Victoria station was equipped with horizontal Milne-Shaw seismographs whose free period of vibration was 12 seconds. They were required to record wave periods of the order of 0.1 second and the results were very poor—in fact the instrument was broken after the first few seconds of the earthquake. (The Wiechert, a shorter-period vertical instrument, had been discontinued in 1945.) Furthermore, paper speeds on these early instruments were slow, the Milne-Shaw being 7.5 millimetres per minute. Reading of accurate time (to 0.1 second) is impossible with such records, and because severe earthquakes might be expected to occur again, it was decided that a modern seismograph should be installed at Victoria.

Where a station is to be equipped with only one sensitive seismograph it is generally agreed that that instrument should be of the vertical-component type. One such instrument designed to record short-period shocks consists of a seismometer (or pendulum) with a period of 1.0 second, driving a galvanometer with a period of 0.2 second, the seismometer being of the variable-reluctance type, with a mass of approximately 250 pounds. The period of such an instrument falls in the frequency range of local earthquakes. The photographic paper recorder revolves at a speed of 60 millimetres per minute, making accurate time-reading possible. A seismograph of this type was purchased in Pasadena, the home of its designer, Dr. Hugo Benioff of the California Institute of Technology, and installed during June 1948 on a pier in the vault at the Dominion Astrophysical Observatory. Immediately the seismologists at Ottawa became aware that earthquake activity near Vancouver Island was somewhat greater than had been indicated by the Milne-Shaw seismographs. Although the new instrument was out of operation for four months in 1949, between June 1948 and August 1951 it recorded 224 local earthquakes.

With only one instrument recording, the small tremors cannot be located because from one record only, distance alone can be computed. Thus, although it was known that there were many earthquakes occurring in the Vancouver Island area of British Columbia, it was not known where the majority of them were centred. When additional instruments became available at the completion of a programme of rock

burst study in Ontario in 1951, it was decided to establish two new seismograph stations in British Columbia. These stations were equipped with three-component (north-south, east-west and vertical) seismometers designed by Dr. P. L. Willmore, and made in Canada by the Sharpe Instrument Company. Their free period is approximately 0.3 second, and they are of the moving-coil type. Recording is done on a Sprengnether paper recorder through Turner 0.03-second galvanometers. One station was located at Alberni in August 1951 under the care of Mr. W. N. Burgess, and the second unit was placed upon a mountain near Horseshoe Bay a few miles from Vancouver, where Mr. W. S. Blacklock performs the daily record changes. A seismologist (the author) was transferred to Victoria from the Ottawa Observatory to be in charge of this network, and to investigate in detail the seismic activity in southwestern British Columbia. Since 1951, annual reports have been presented in the *Publications of the Dominion Observatory* under the title "Canadian West Coast Earthquakes 19—", discussing the results of these investigations. Late in 1954, the period of the instrument at Horseshoe Bay was increased by replacing the Willmore-Sharpe seismometers with Willmore-Watt instruments of the moving-magnet type. This was made necessary because the ships of the Black Ball Ferry dock some 100 yards from the seismic station; each time that a ship rammed into the pier when it landed, or churned up the water upon leaving the pier, the recording instruments were disturbed for three to four minutes. The longer-period seismograph acts as a filter, eliminating the disturbing "noise".

Meanwhile at the Dominion Astrophysical Observatory an addition was being made to the office buildings, and, on the ground floor of the new section an area was set aside for seismological equipment. Two cement piers were set on solid bedrock, one for the recorders and one for the seismometers, in a separate, insulated room. New Benioff three-component seismographs were installed. These short-period instruments operate at the same constants as the former vertical instrument. A three-record drum registers the earth motion in a separate room. The seismometers are each equipped with two series of coils, one to match the short-period (0.2 second) galvanometer, and one to match the long-period, (80 second) galvanometer. The complete unit is therefore capable of recording the very long-period waves of any earthquake, as well as the very short-period waves of a local shock. At a seismograph station the magnification of the instrument, usually adjustable, is limited by background noise. Near the coast these noises, or microseisms as they are called, are stronger than at central continental locations. The

microseisms range in period from 1-second waves caused by wind or surf to 6- to 8-second waves caused by huge lowpressure fronts moving over shallow seas. The magnification of the seismograph is adjusted so that the microseisms are not large enough to interfere with the reading of the onset of any earthquake. At Victoria the gain permitted is of the order of 40,000, or in other words, recorded amplitudes are about 40,000 times the actual ground motion. The Milne-Shaw instruments were moved to the new vault and continue to give satisfactory records of strong earthquakes. The Victoria seismograph station, as complete as any in Canada, includes a photographic darkroom, as well as an entrance hall which serves as a radio room and a record storage area.

Late in 1953 the Victoria office was asked to install three seismographs in the Crowsnest Pass area along the southern portion of the Alberta-British Columbia Boundary to record bumps in the coal-mines near by. These seismographs of the short-period Willmore-Watt type, using daylight recorders, are to be replaced later by one more-sensitive unit to be located in the mountains at about the latitude of Calgary.

The seismograph instruments described receive the earth-waves from a tremor and record them on photographic paper for future study. An important part of this study is the determination of the time of arrival of the various earth-waves at the respective seismograph stations. On each record a time mark is placed once a minute by a standard chronometer. (Our most accurate chronometer has a loss of time rate of ten seconds in five months.) To correct each station to absolute time it is necessary to record each day some standard time signal. At the network stations the CBC Dominion Observatory time signals are easily recorded. At the central station of Victoria, the time signals of the Mare Island, San Francisco station are recorded four times daily to provide more accurate time determinations.

Earthquakes

It is generally known that the circum-Pacific region is an active earthquake area, all portions from the Aleutian Islands in the north to southern Chile in the south having experienced a severe tremor at one time or another. The stretch of coast from Alaska to California was thought at one time to be relatively free of serious disturbances, but a glance at the earthquake history of British Columbia is sufficient to show that there have been strong earthquakes, although fortunately none was close enough to a populated area to arouse much attention. A strong jolt in 1872, probably centred about a hundred miles east of Vancouver, was perhaps the most severe event, although there were at that time few

people located in the area to feel and report it. On January 11, 1909 the Gulf Islands were jarred by a moderate tremor, and mention has already been made of the 1918 shock off the west coast. Between these events, minor tremors causing no damage were continually being felt.

At about 10:30 a.m. P.S.T. on Sunday, June 23, 1946 earthquake activity in British Columbia was suddenly brought to the attention of many residents of the south-western part of the province by an earthquake centred in the north Gulf of Georgia, approximately opposite Campbell River. Dr. Hodgson has described in detail the effects of this earthquake in the October 1946 issue of this JOURNAL. It is sufficient to note here that one life was lost, and many thousands of dollars of damage was done. The disturbance was measured at Pasadena as of magnitude 7, and from field evidence the intensity at the origin was VIII or IX. (Magnitudes are obtained from measurements of the recording of an earthquake made on a seismograph; intensities at the origin on a scale of XII are estimated from the visible after-effects of an earthquake and from reports of the experiences of persons feeling the shock.) Following the earthquake, only a few after-shocks were reported, and none was recorded, probably because of the insensitive nature of the seismographs at Victoria at that time. It was not until 1951 that seismic activity in the area could be studied with a network of stations, and then no after-shocks were recorded until late 1954. It is, however, unusual to have a major earthquake in an area, with no after-shocks.

There is no doubt that the Pacific region is subject to severe earthquakes, for between the time of the 1946 earthquake and the establishment in 1951 of the network of seismographs, two additional intense earthquakes were experienced in the coastal area. The lesser of the two, occurring on April 13, 1949, with epicentre near Olympia, Washington, was felt in areas of Canada adjacent to the state of Washington. No damage was reported in Canada, although in Washington damage amounted to more than one million dollars.

The stronger earthquake, occurring on August 22, 1949, at 8:01 p.m. P.S.T., with epicentre at 54.2°N., 133°W., northwest of Graham Island in the Queen Charlotte Islands group, was much greater in energy release at the centre of the disturbance. The Pasadena magnitude was 8.2, but no estimate is available of the intensity at the origin. This earthquake was followed on August 23, at 12:24 p.m. P.S.T., by an after-shock in itself as strong as the 1946 earthquake. The main event must be rated as one of the earth's major earthquakes.

On the Queen Charlotte Islands, although reports are scarce, the earthquake was felt severely. There is a report of a geologist working on the

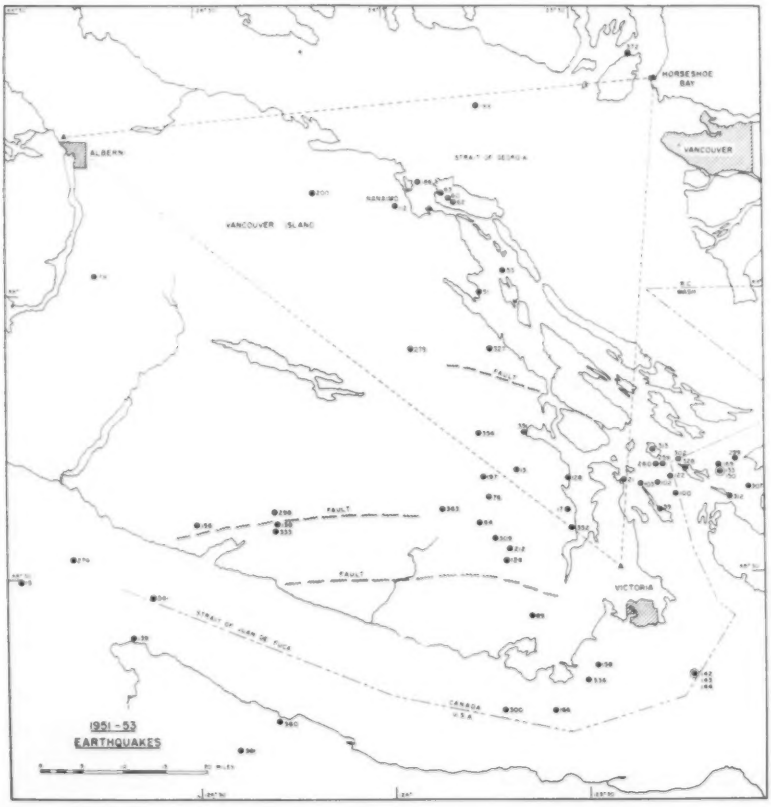
north-west tip of Graham Island who was unable to stand up due to the violent shaking of the ground. In the Lockport area two boat captains, who at the time were on land with their boats beached, reported that they had to hang on to trees to maintain their balance. They mentioned also that the water was swirling wildly where their boats were resting, and that there were many landslides. At Delkatla the bridge "writhed like a snake", and the ground was cracked. At a lodge near by, the horses could not be controlled even one hour before the event. The Prince Rupert Daily News states that just across Delkatla Slough the earth fissured, one crack fifty feet long and six inches across being so deep its bottom could not be seen. Many trees were felled, and in one house a piano was shifted. As far away as Prince George the people were alarmed and ran into the streets. At Cumshewa Inlet logging camp a tank containing many gallons of fuel oil was destroyed, at considerable loss to the owner. These are the only reports of damage that have come to our attention, but the earthquake was felt as far distant as Jasper to the east and Seattle to the south. Placing the origin in the Queen Charlotte Islands, this represents an area of some 2,220,000 square miles, half of which is under the ocean.

Following the earthquake, the residents of Cumshewa Inlet were reported as anxious to move out of the area, for between August 22 and October 1 they felt 107 after-shocks, that of August 23 being the most severe. At Victoria, a distance of 500 miles, the Benioff seismograph recorded 60 after-shocks.

Reports and written accounts of earthquakes in this area are scarce, but it appears that there have been many with epicentres just west of the Queen Charlotte Islands, and a few close to the mainland of British Columbia. This statement is based upon a search of newspaper files and upon reports of official epicentre-locating agencies such as the United States Coast and Geodetic Survey. While the Benioff seismograph alone was operating at Victoria, there were many earthquakes recorded but few located. Since August 1951 the network of seismographs has made it possible to assign an origin to many of the small local shocks, and during the intervening four-year period 622 earthquakes have been recorded, and of these 225 have been located. Naturally, the co-ordinates of the more precisely determined origins lie within the triangle made by the Horseshoe Bay, Alberni and Victoria seismograph stations. A map is included to show the distribution of epicentres within this triangle during 1951–52–53. Geological fault lines, mapped by Clapp in 1913, are indicated. The most concentrated group of epicentres shown is that in the Gulf Islands, from Saanich peninsula to Orcas Island. For

example, late in February 1952 three earthquakes with centres in this area were felt in Victoria and surrounding districts in as many days. No damage was reported, hence the intensity rating is of the order of III. The seismograph recordings indicate that none of these tremors could have been deeper than 15 miles.

The Saanich peninsula itself appears to have been free of any disturbance during this period, but across the Saanich inlet there were several tremors, again very small, but indicating to the seismologist what appears to be a more active area. In fact, there appears to be a major fault zone striking south from Nanaimo to Juan de Fuca Strait. This, however, is quite contrary to surface geological mapping, as in-



dicated by the fault lines shown on the map. Suggestions have been made that some of the seismograph recordings were caused by cave-ins in abandoned mine workings, since the seismic record does not differentiate between a man-made disturbance and an earthquake. In support of this suggestion, epicentres 60, 62 and 63 are along an abandoned mine-channel. Further, there is a possibility that some of the epicentres shown in the Strait of Juan de Fuca are depth-charge explosions, indeed many known cases of such explosions have been removed from the map. A few tremors occurred nearer Jordan River and along the fault line, one of them being felt as far distant as Vancouver.

The scattering of the other epicentres can perhaps be expected. Attention is directed to a group of earthquakes in the Mission-Abbotsford region. One earthquake which was felt there on February 6, 1952 was investigated in the field. It appeared that the earthquake was felt with about the same intensity from Stave Lake on the north to Sumas on the United States-Canada border, where the investigation ended. Several tremors appear to have occurred near Mount Baker, and there is the possibility that such may be associated with past volcanic activity. The strong earthquake of 1872 may perhaps have had its origin in this area, but an epicentre further east fits the evidence better. A few centres of disturbance have been located in the high mountains north of the Fraser River.

Seismic disturbances in south-western British Columbia appear to be divided into two groups, if apparently stray earthquakes are neglected. One zone of activity includes the tremors on Vancouver Island and possibly the few in Barkley Sound, the Gulf of Georgia, the Mission area and those along Jervis Inlet. This series of earthquakes extends south through the Seattle area and stops just south of Tacoma at the end of Puget Sound. The other zone lies further west of Vancouver Island at approximately 49°N. latitude and 130°W. longitude. This latter area is much more active than the zone lying closer to the continent, earthquakes of magnitude 6 to 6.5 being a regular occurrence. Perhaps the residents of the British Columbia coast are fortunate in having near by an area where energy can be released without harm to anyone.

Interest in seismic activity along the Canadian Rocky Mountain Trench has increased in recent years. United States geophysicists have pointed out that in Montana and further south the belt of moderate seismic activity parallels the trenches just west of the Rocky Mountain Range, but that the belt appears to end at the international border. At the present time we are investigating activity in that area with the seismographs of the Crowsnest Pass. There were a few small tremors in

the Rocky Mountain Range, and three disturbances are listed as having been felt in the trench area. However the intensity of these tremors was small compared with the intensity of those south of the border.

The three seismographs at Alberni, Horseshoe Bay, and Victoria make it possible to plot the seismic activity in the south-west corner of British Columbia, and it is likely that a similar triangle of stations placed anywhere along the coast would record equally as many earthquakes. With more sensitive seismographs, larger triangles could be used, so that within a few years the populated portion of the coastal region could well be covered. It would be interesting also to investigate the occurrence of earthquakes in the interior of the province. The purpose of such a coverage of seismic stations is to plot active seismic areas, so that it may be possible to say *prior* to the event that an earthquake such as that of 1946 may happen in one particular region but that it is unlikely to happen in another region a few miles away.

PLAQUE UNVEILED ON THE FIRST ASTRONOMICAL OBSERVATORY IN CANADA

By J. E. Kennedy

The decision of the Historic Sites and Monuments Board of Canada to mark the Observatory at the University of New Brunswick with a plaque has been recorded in an earlier issue of this Journal (vol. 48, p. 220, 1954). The unveiling ceremony was held on May 10th, 1955, at 11 a.m., as one of the Encaenia Week Functions at the Provincial University. The weather—cloudy and cool with a fairly strong wind—could not be described as favourable for an outdoor event, but the large attendance gave evidence of a renewal of local interest in astronomy and in this historic Observatory.

The unveiling ceremony was conducted by University President Colin B. Mackay with Dr. C. McN. Steeves, Dr. A. G. Bailey, Dr. J. F. Heard and Professor J. E. Kennedy participating in the function.

In welcoming the many visitors to the University, Dr. Mackay made particular reference to the presence of the Premier of New Brunswick and Mrs. Flemming, His Worship the Mayor of Fredericton and Mrs. Wright, and members of the local chapters of the I.O.D.E. He also extended a sincere welcome to other distinguished guests, among whom was Mrs. F. T. Dunlop of Saint John, a grand-daughter of William Brydone Jack.

The following excerpt, taken from President Mackay's introductory remarks, will be of interest to the readers of this Journal:

"In 1947 the Government of Canada recognized the University of New Brunswick as the birthplace of Canadian literature when it placed on this campus the monument in memory of Sir Charles G. D. Roberts, Bliss Carman and Francis Sherman. A year ago we unveiled a tablet in memory of Canada's first native born novelist, Julia Catherine Beckwith Hart.

"This campus has been recognized not only for those distinguished men and women who have lived and worked here, but also for its old and historic buildings which have played such a significant part in the growth of higher education in Canada.

"A few years ago the Historic Sites and Monuments Board marked the Arts building as the oldest existing university building in Canada. To-day, on the recommendation of that same Board, the Dominion Goverment is officially recognizing the University's Observatory as the First Astronomical Observatory in Canada.

After the unveiling ceremony, shown from left to right are: Dr. J. F. Heard, Director of the David Dunlap Observatory and Head of the Department of Astronomy at the University of Toronto, Professor J. E. Kennedy of the Department of Physics, U.N.B., Dr. A. G. Bailey, New Brunswick representative on the Historic Sites and Monuments Board of Canada, Dr. Colin B. Mackay, President of U.N.B., and Dr. C. McN. Steeves, a member of the University Senate.

"It was a natural outcome of the efforts of Sir Howard Douglas to re-establish the University on a firm foundation with the construction of the Arts building in 1828, that the University should not be long in expanding its scientific facilities. The natural resources of the province were opening up and commerce and navigation posed many problems in the fields of mathematics, physics and astronomy. At that juncture in the history of the province, it was fortunate indeed that a young Scotsman with scientific training should have accepted a professorship at this University. His energy and enthusiasm soon made themselves felt at what was then King's College and the records of 1847 reveal that consideration was being given to the purchase of astronomical equipment. The telescope was acquired the following year and in 1851 the Observatory was completed at a cost of £170.9s.7d."

To unveil the plaque and read the inscription, the President called

upon Dr. C. McN. Steeves, a senior member of the University Senate, who has been untiring in his efforts to preserve and restore the Observatory. Dr. Steeves was one of the members of the class of 1905 who had returned to the University to celebrate their fiftieth anniversary during Encaenia Week.

The inscription on the plaque is as given:

FIRST ASTRONOMICAL OBSERVATORY IN CANADA

Built in 1851 at the instigation of William Brydone Jack, professor of mathematics, natural philosophy and astronomy; President of the University of New Brunswick, 1861–85. Schooled in the traditions of the Scottish universities, he equipped the observatory with the best instruments of the day. In collaboration with Harvard observatory he determined the longitude of Fredericton and other places in New Brunswick and corrected errors in the international boundary.

Dr. Bailey, Dean of the Faculty of Arts, and New Brunswick representative on the Historic Sites and Monuments Board was requested by the President to make the formal presentation of the plaque to the University, on behalf of the Government of Canada. Before performing this official duty, Dr. Bailey read a telegram received from the Honourable Milton F. Gregg, Minister of Labour in the Federal Cabinet, expressing his regret that pressure of work at Ottawa made it impossible for him to attend the ceremony.

The University was indeed fortunate to have one of Canada's distinguished astronomers, Dr. J. F. Heard of the David Dunlap Observatory, as the speaker for the occasion. The President called upon Professor J. E. Kennedy of the Department of Physics who introduced Dr. Heard to the gathering with the following words:

"In 1851, William Brydone Jack completed this Observatory and applied for the chair of Mathematics at the University of Toronto. Dr. Jack was not selected for this appointment, but spent the remainder of his academic life in the service of this University. It seemed appropriate that the University of Toronto, having made this ceremony possible by their actions of over a century ago, should also make it successful by sending the Head of their Department of Astronomy to address us to-day.

"Dr. J. F. Heard has been associated with the Department of Astronomy at Toronto for the past twenty years, except for his period of service in the Royal Canadian Air Force during the second world war. In 1952, he was appointed Head of the Department and Director of the David Dunlap Observatory. Last year, he acted on behalf of all Canadian amateur astronomers as President of the Royal Astronomical Society of Canada.

"We are very pleased to welcome Dr. Heard on his first visit to Fredericton and to the campus of the University of New Brunswick."

Dr. Heard then delivered the address which follows, linking together the "all-but-forgotten" past, calling attention to the present, and expressing a hope for the future.

"On the occasion of the unveiling of this plaque marking the oldest Astronomical Observatory in Canada, it is my privilege to bring to the University of New Brunswick the congratulations of the University of Toronto and of the Royal Astronomical Society of Canada.

"In his interesting enquiry into the history of this Observatory, Professor Kennedy has shown that without doubt it *is* the First Astronomical Observatory in Canada. Indeed it was a good many years after 1851 before the Government of Canada recognized the need for a government astronomical observatory and took steps to found the Dominion Observatory at Ottawa.

"To me it is a very interesting fact that many of the observatories which were founded in the 17th, 18th and 19th centuries have shared a common *raison d'être*, namely the search for longitude. This was a problem which had plagued astronomers and geographers from the time of Copernicus and Christopher Columbus. Latitude could be measured with relative ease even in the days of Columbus, but the longitude remained elusive, especially at sea and beyond the continent of Europe. Because he had no way of measuring longitude, Columbus believed that he had reached the Orient. The Jesuit Fathers of our country repeatedly sought, all during the 17th century, to establish the longitude or the distance from Paris of their missions and settlements. To this end they eagerly observed every eclipse which was predicted by the astronomers in France.

"The situation had become so acute by the middle of the 17th century that the British Government offered a prize of £20,000 for a practicable means of determining longitude at sea and overseas. Out of this competition grew the need for an astronomical observatory to test the proposals put forward, and in 1675 the Royal Greenwich Observatory was founded. Eventually practicable methods were developed, thanks largely to the invention of the chronometer by the Yorkshire carpenter, John Harrison. The use of the chronometer for longitudes put new tasks upon astronomers, namely the need for increasing precision of time determination by the stars, the adjustment of field instruments and the training of surveyors in astronomical observations.

"There is no doubt, as Professor Kennedy has shown, that your renowned Dr. William Brydone Jack founded this Observatory with these

very things in mind. It is tempting to believe, moreover, that the aggressive astronomical work which Brydone Jack pursued here played a part in the development of astronomical surveying which, later in the 19th century, when the West was added to Canada, became a necessary responsibility of the Government of Canada and led, in turn, directly to the founding of the Dominion Observatory.

"Then, apparently by some accident, the interest in astronomy here lapsed—as it has elsewhere from time to time—and this Observatory and the work of that pioneer Canadian astronomer were all but forgotten. But the stars have endured for about five billion years, and here again, after a mere seventy, risen like the Phoenix, is a splendidly refurbished little Observatory ready once more to inspire students with the wonder and the spirit of enquiry which have always characterized man's approach to the heavens.

"In offering my congratulations to you, I would like to express the hope that those of you who have been responsible for this renewal of astronomical interest will find the encouragement which your efforts merit. To be more specific, I hope that courses in astronomy will be added to the University curriculum. I hope, also, that a Fredericton Centre of the Royal Astronomical Society of Canada will come into being, and flourish under the aegis of the University teaching staff. May the City of Fredericton and the University of New Brunswick once more, as in the days of William Brydone Jack, play important roles in Canadian Astronomy."

Dr. Mackay expressed his thanks to Dr. Heard and noted the efforts of Professors Stevens and Kennedy of the University Faculty in supervising the restoration of the Observatory and in rebuilding the telescope. In closing, the President invited all attending the ceremony to avail themselves of a conducted tour through the Observatory where some of the historic instruments used in making early astronomical observations were on display.

As an added feature, there was a special exhibit of old documents and books relating to the pioneer work of William Brydone Jack, which proved interesting to the many visitors. This exhibit had been arranged for the occasion by Mr. Robert Rogers, Archivist at the University of New Brunswick Library.

While the unveiling of the plaque brings to completion one phase in the restoration of this historic Observatory, let us hope that the second phase may see the fruition of the challenge presented to us by Dr. Heard.

RADIO SCIENCE AND ASTRONOMY

By A. E. Covington

Within the past decade the rapidly developing techniques of the radio laboratory have been applied to further our understanding of the universe in the sense of observational astronomy. This association of a very new science with one of the oldest of sciences, seems natural in view of the original experiment of Hertz in 1887. These showed that light waves and radio waves are electromagnetic disturbances which differ only in wave-length. Once this similarity had been established, it was realized that many of the well known optical experiments could be appropriately translated to corresponding radio experiments. Thus, about 1900 it seemed very logical to expect the thermal emission from a hot body such as the sun to extend from the known region of short wave-length —the visible optical region—into the newly-discovered wave-length region of the Hertzian waves. Radio pioneers attempted to find this solar radio emission but none was found; the early equipment of the pioneers was not sensitive enough to measure such small intensities. It remained for later investigators, working with greatly improved equipment about 1943 to find this emission as an unexpected result of other investigations.

The early science of radio was soon concerned with the important task of using radio waves to communicate from point to point on the earth's surface. First, short distances were spanned and finally, through perseverance on the part of Marconi, signals were transmitted across the Atlantic Ocean in 1902. The explanation of this unexpected transmission from one point to another point below the visible horizon required a reflecting layer in the upper atmosphere. Through a study of the propagation of radio waves man had come into contact with the upper regions of the earth's atmosphere which were required to be highly ionized in order to provide the reflecting surface for the radio waves. About the same time, the existence of such an ionized layer was also required to explain the daily variations of the magnetic compass.

In 1925 new radio techniques were employed by Appleton and Barnett in England, and by Breit and Tuve in the United States, to give detailed characteristics of the ionosphere. The method of the latter workers used the known velocity of propagation of radio waves, together with the observed travel time of a pulse of radio waves, in order to find the height of the layer. Ultimately this principle was incorporated into radar. After several years of study the complex nature of the reflecting layer was out-

lined and it was recognized that the layers were subject to control by the sun. In 1935 other temporary ionizations in the upper atmosphere were related to the passage of meteors, and still other abnormal effects were related to geomagnetic activity.

Radio equipment had been made exceedingly sensitive. In 1931 Jansky of the Bell Telephone laboratories was endeavouring to find the origin of some of the background noises which may be heard from any good short-wave receiver operating in the region of 20 megacycles/second. An unexpected residue of radio noise of constant magnitude could be traced as originating from the centre of our galaxy. Contrary to expectations no emission from the sun was found. Shortly afterwards, Grote Reber, the only amateur radio-astronomer at that time, saw the need for a large radio-telescope to find the detailed distribution of galactic noise over the sky. He built and operated such an instrument—a 30-foot parabolic reflector—and for many years his contours were the only ones available. With the exception of Reber, no one pursued this discovery until after the Second World War.

Throughout this conflict there was a great development of radio technique and much equipment put into operational use. Its wartime uses led to two astronomical discoveries: solar radio emissions were unexpectedly detected by radar networks, and radar echoes from meteors were observed on equipment used to detect V2 rockets in England. After the war, the time had come for the active pursuit of the scientific observations which were incidental to other work. Many laboratories throughout the world became actively engaged, and unexpected fields opened out for the radio-astronomer. There are now many publications, and most of the subject matter of optical astronomy has been investigated. Topics range from the near and distant galaxies, interstellar neutral hydrogen, super-novae remnants, galactic nebulae, meteors, sun, moon, and most recent of all, the emission of radio noise from the planet Jupiter. In a very practical sense, the radio emission from the sun and moon has been picked up by a radio-telescope serving as a radio sextant. This gives sufficiently accurate information for ordinary ship navigation and has the tremendous advantage over visual means by being able to work through clouds and overcast.

Many of the publications which record the original work on radio-astronomy have been devoted to radio sciences, and hence are sometimes not readily accessible to the astronomical reader. At first glance, astronomical papers or notes of astronomical activities from a radio or electrical engineering institution may seem out of place in an astro-

nomical magazine, but past history and present results show that this is only indicative of a new phase of astronomy.

National Research Council,
Radio and Electrical Engineering Division,
Ottawa.
May 20, 1955.

NOTES FROM THE NATIONAL RESEARCH COUNCIL

Division of Radio and Electrical Engineering

In 1946 the Radio and Electrical Engineering Division of the National Research Council commenced investigations, under the direction of A. E. Covington, on the emission of radio noise from the sun on a wave-length of 10.7 centimetres. The techniques and equipment which had been designed for radar sets in the Division were modified for use in this new field. The initial work was carried out at the Metcalfe Road Field Station, and since considerable microwave radio interference was experienced there, a new site was acquired in 1948 at Goth Hill in South Gloucester. This is located fourteen miles south of Ottawa and is the present location of the solar noise observatory.

The observatory is now operating two radio-telescopes which monitor the total emission from the sun: one instrument is the original four-foot parabolic reflector which has been in service since 1946, while the second one is a recently-installed reflector of ten-foot diameter. The 150-foot long array has been used to give directional information of radio waves from the sun, and is currently being modified to operate as an interferometer, in order to improve the resolving power; this is a third radio-telescope.

A long series of regular observations of the sun at a wave-length of 10.7 centimetres was commenced in 1946, and will be continued into the future. Comparison with optical observations made at other observatories has shown that there are three components of radio noise: an emission originating from the undisturbed solar atmosphere, an emission varying slowly from day to day which originates from the vicinity of sun-spots,

and a somewhat rare impulsive component of short duration which is associated with the appearance of solar flares. These emissions have been shown to originate at a level associated with the solar chromosphere —the transition layer above the photosphere and below the corona. The continuous monitoring of the radio emission at this wave-length appears to provide convenient indices of solar activities and will be of use to those studies in which special events on earth may be traced to the occurrence of a flare on the sun. Particular emphasis will be placed on this work for the International Geophysical Year (1957–58) when solar activity is of particular interest in the fields of ionospheric research, cosmic rays, auroral studies and magnetic storm analysis.

In 1947 the Radio and Electrical Engineering Division, together with the Dominion Observatory, initiated a combined programme of meteor research. The radar observations were under the direction of Dr. D. W. R. McKinley, who developed a 33 megacycles/second radar set at the Metcalfe Road Field Station so that echoes from meteors passing through the upper atmosphere could be detected readily. Dr. Peter M. Millman of the Dominion Observatory conducted the visual, photographic and spectrographic work. One of the most important contributions of this programme to astronomy has been the conclusion that few, if any, meteors down to the eighth magnitude can be of interstellar origin. A few determinations of the complete orbits of meteors have been made by triangulating points of the ionized meteor path from three independent radar stations and have yielded elliptical orbits.

Recently a new Upper Atmosphere Research Section has been formed in the Radio and Electrical Engineering Division. Dr. Millman was appointed to head this section, and joined the National Research Council in January 1955. The activities of this new section will include both meteor and auroral observations, as well as the study of associated ionospheric problems. Meteor research in co-operation with the Dominion Observatory will be continued during certain selected periods of meteor showers. At the present time the travel paths of radio waves between Ottawa and Scarboro are being studied. Of particular interest in this research is the part played by meteors in reflecting the radio waves transmitted between these stations, a phenomenon known as "meteoric forward scatter".

The International Geophysical Year, which will run from July 1957 to December 1958, will feature co-operative observations among the participating nations. Already, more than thirty-six countries have indicated their intentions of conducting geophysical research during this period. Canada's contributions will be of particular value because of our

geographical location with respect to the north magnetic pole and to the zone of maximum auroral occurrence. The Upper Atmosphere Research Sections' efforts in this connection will be directed principally toward radio, photographic and visual observations of the aurora and meteors.

Dr. Allen G. McNamara, who for the past few years has been carrying out auroral research at the University of Saskatchewan, came to Ottawa in September 1954 to continue his investigations as a member of the Section for Upper Atmosphere Research. He has developed a continuously-operating radar set, at a wave-length of six metres, to detect and record automatically the auroral echoes. This radar has been operating in Ottawa quite satisfactorily since mid-April of this year. Echoes have been obtained on a number of nights, and on some occasions the echoes were present almost continuously throughout the entire night.

Experience gained with this prototype radar is being applied to the design of special equipment for the International Geophysical Year. These radars will be compact, simplified sets, designed for reliable and unattended operation. They will be placed at semi-isolated locations in Northern Canada, both north and south of the auroral zone. Photographic and intensity records of the visible aurora will also be obtained at these and other Canadian stations during the International Geophysical Year.

A recording magnetometer has also been in operation at the National Research Council since March of this year. Variations in the declination, *D*, of the earth's magnetic field are measured and the magnetic records are compared with those from the auroral radar. The magnetic fluctuations occur at times of auroral disturbances and are associated with the presence of radio echoes from the aurora.

A. E. C.

NOTES FROM OBSERVATORIES

David Dunlap Observatory

Observing conditions during the winter and spring have been average. Progress was made in particular on spectrographic observations for a programme of stellar luminosities undertaken by Dr. Oke. Dr. MacRae and Mr. Bakos, using the new photoelectric photometer with the 19-inch telescope, have completed a series of observations of magnitudes and colours of 162 stars selected from a thousand stars recently studied here for radial velocity and luminosity. These will be used to control photographic measures of the magnitudes of all these stars which are being done with the co-operation of the Hamburg and the Warner and Swasey Observatories.

Good progress has been made in the construction of a photoelectric spectrophotometer designed by Dr. Oke and Dr. MacRae. This is to be used with the 74-inch telescope.

Dr. C. A. Chant, Director Emeritus, celebrated his ninetieth birthday at Observatory House, May 31st. This was also the twentieth anniversary of the opening of the Observatory.

Promotions announced recently at the University include those of Dr. MacRae, from Associate Professor to Professor, and Dr. Helen Hogg from Assistant Professor to Associate Professor.

Dr. William R. Hossack who held an appointment as Lecturer in Astronomy since 1953 has resigned to accept a position with Defence Research Board at Ottawa. The loss of Dr. Hossack from the staff will be felt particularly in the field of electronic developments to which he contributed significantly during his stay.

Dr. Helen Hogg will be on leave of absence from the Observatory for part of the coming session to be Program Director for Astronomy for the National Science Foundation in Washington until June 1956.

Miss Olga Boshko, of the Dominion Observatory, has been awarded the Frank S. Hogg Memorial Fellowship to pursue graduate studies in astronomy at the University during the 1955–56 session.

During the 1954–55 session the general course in astronomy for teachers was given at the University, the instructors being Prof. Ruth Northcott, Dr. Oke and Dr. Hossack. This course is offered every third year and is given in the evenings for the benefit of those teachers, resi-

dent in Toronto, who are working towards a B.A. degree in the Department of University Extension. It will be followed by a summer course of a similar nature offered for the benefit of teachers not resident in Toronto; Dr. J. B. Oke will be the instructor. Another University Extension course in astronomy, which is offered each year, is the evening tutorial course which is open to any who are interested. During the 1954–55 session there was an enrolment of 80 in this course which was given by Dr. MacRae.

During the spring of this year Mr. Longworth, the Observatory Mechanician, re-aluminized the Cassegrain secondary of the 74-inch, the objective of the 19-inch telescope and a number of smaller mirrors.

The Astronomer Royal, Sir Harold Spencer Jones, accompanied by Lady Spencer Jones, visited the Observatory and the University on May 5th to 8th. Sir Harold spoke at an astronomy colloquium on "The Earth's Rotation and its Variations"; and addressed a joint meeting of the Royal Canadian Institute and the Toronto Centre of the Society on "Life on Other Worlds".

Dr. Helen Hogg was the guest speaker at the annual dinner meeting of the Rochester Branch of the Optical Society of America on May 10th. She spoke on "The Milky Way".

Dr. Heard represented the Observatory and the Society at the unveiling of a plaque marking the oldest astronomical observatory in Canada at the University of New Brunswick on May 10th. This event is reported elsewhere in this number of the JOURNAL.

Dr. Heard and Dr. Oke presented papers at the Princeton meeting of the American Astronomical Society April 4th to 6th. Miss Northcott also attended the meeting.

At the meeting of the Royal Society of Canada in Toronto, June 6th to 8th, papers were presented by Dr. Hogg, Miss Northcott, Dr. MacRae and Dr. Heard. Dr. MacRae also took part, by invitation, in a symposium on the distribution of the high-temperature stars.

Summer assistants at the Observatory include Donald Morton, Basil Kerr and Marion Burgess of the University of Toronto and Gordon Wiseman and Arlyne Rosenblat of the University of Manitoba.

Planning to attend the General Assembly of the International Astronomical Union in Dublin this summer are Dr. Heard, Dr. Oke, Dr. Hogg and Miss Northcott.

J. F. H.

UNIVERSITY OF NEW BRUNSWICK OBSERVATORY, FREDERICTON, N.B.

U.N.B. Library Acquires Valuable Jack Letters. During the past two years, it has become apparent that Dr. William Brydone Jack was one of the pioneers in the field of Canadian astronomy. In 1951, Dr. E. E. Brydone Jack, his son, donated a large amount of Dr. Jack's correspondence, as well as several lectures on astronomy, to the New Brunswick Museum in Saint John.

A search of this material showed that considerable correspondence had been exchanged between Dr. Jack and Professor W. C. Bond of Harvard College Observatory, and also, in the period 1854–1858, between Dr. Jack and Sir G. B. Airy, the Astronomer Royal at the Greenwich Observatory.

Dr. Allan F. Cook made a search of the Archives in the Widener Library at Harvard and located five letters from Dr. Jack to Professor Bond. The Archives Section of the U.N.B. Library obtained these on photostatic copy in July 1954.

In searching the files of the Greenwich Observatory, the present Astronomer Royal, Sir Harold Spencer Jones, located nineteen letters which have been reproduced in typescript and photostatic copy. This material arrived at the University of New Brunswick in February of this year.

This correspondence will be of great value in correctly assessing the contribution Dr. William Brydone Jack made to early Canadian astronomy.

J. E. K.

REVIEW OF PUBLICATIONS

Tables of Functions and of Zeros of Functions, National Bureau of Standards Applied Mathematics Series–37. Pages ix plus 211; 8 x 10½ in. Washington 25, D.C., Government Printing Office, 1954. Price $3.00.

This is the first of several volumes in which shorter tables of functions which are of use in mathematical physics are collected. The present volume presents ten tables of special functions such as integrals of Bessel functions, exponential integrals, Struve Functions, and values of $x^n/_{n!}$ In addition there are eight tables of zeros of such functions as the Legendre and Laguerre polynomials and of various kinds of Bessel functions. Each table is preceded by a discussion of the underlying theory, the bibliographical background, and numerical illustrations.

J. B. O.

The Illumination and Polarization of the Sunlit Sky on Rayleigh Scattering by S. Chandrasekhar and Donna D. Elbert. (Trans. Amer. Phil. Soc., N. S. vol. 44, pt. 6, pp. 643–728, 1954). Pages 85; 9¾ x 11¾ in. Philadelphia, The American Philosophical Society, 1954. Price $2.00.

The brightness and polarization of the sunlit sky were first explained qualitatively in 1871 by Lord Rayleigh in terms of a scattering law now associated with his name. Since then many observations of the polarization of the sunlit sky have been made but no quantative theory has been worked out. In view of the relevance of this problem to meteorological and upper-atmosphere research, these authors have studied the problem. Their results are presented in this paper.

The problem consists essentially of solving the appropriate equation of transfer under the condition that the atmosphere scatters light according to Rayleigh's law. Since the numerical solution of the equation is extremely complicated, nearly all of the paper is devoted to tables of the appropriate functions involved. The final results are presented in both tables and diagrams. Two comparisons are made between the theoretical and observational results. The observed and computed positions of the lines where polarization is absent agree very well. Also the degree of polarization observed and predicted by theory agrees as well as can be expected. In conclusion, this paper will prove very valuable to anyone interested in problems connected with the atmosphere of the earth.

J. B. O.

VARIABLE STAR NOTES

American Association of Variable Star Observers

By MARGARET W. MAYALL, *Recorder*

Miscellaneous notes on some of the more interesting activities of the A.A.V.S.O. variables during 1954 and early 1955.

The times of maxima and minima of long period variables are not necessarily the dates of brightest and faintest magnitudes, but are determined by superimposing a mean light curve on the observed curve and marking the maximum and minimum from the best fit of the two curves. This method eliminates many observational errors, and makes use of the whole curve and not just a few points.

000339 *V Scl.* A bright maximum, magnitude 9.5, the latter part of October, followed three faint maxima.

001755 *T Cas.* A very marked still-stand occurred before the current maximum. The star was at minimum (mag. 12) in the middle of July, rose to about 8.3 by mid-October, dropped to nearly 9th mag. the last of December, then rose to a fairly bright maximum of about 7.4 near the predicted time of March 21, 1955.

001838 *R And.* A bright maximum (6.3) occurred the first of August, about 12 days earlier than the predicted time.

003179 *Y Cep.* This circumpolar variable remains poorly observed in spite of the attention I have called to it in the past. It varies from 9.6 to 15.2, with a period of 332 days. Strangely enough, it is better observed at minimum than at maximum.

005840 *RX And.* AZ Camelopardalis-type variable. It was nearly constant at 11¼ mag. for more than two years, until in September it began to vary about two magnitudes, from 11 to 13. It varies rapidly, with a period of 14 days.

010884 *RU Cep.* A good maximum was observed the first of February 1954, about 100 days after the previous one, but very few observations of it have been received since then. It varies from about 8½ to 9½ and should be followed with small instruments.

011041 *UZ And.* A bright max., 9th mag., the first of March 1954, followed by a more normal one, about 10½ mag., in the middle of January 1955.

013238 *RU And.* The range has increased to about two magnitudes, after more than ten years of about one mag. variation. Early A.A.V.S.O. observations, before 1920, showed a range of nearly four mags., which continued until the late 1930's.

021403 *o Cet.* The most recent maximum of Mira occurred about February 1, mag. 3.9, 10 days or so before the predicted date. The exact date of maximum cannot be determined until we have more observations of the descending branch. This maximum seems to be very narrow for a rather faint maximum.

022426 *R For.* A bright max., 8.2 mag., in the middle of July, followed two 9½ magnitude maxima.

025050 *R Hor.* A faint max., about 6½ magnitude, was observed 20 days after the predicted time of maximum. The two preceding max. were both brighter than six.

032443 *GK Per, Nova 1901.* A well-defined maximum was observed the last of February 1954. The star rose from 13 to 12 and back down again to 13 in 50 days. Since then it has been fairly constant at 13th magnitude.

042215 *W Tau.* Nearly constant at 10.7 from the last of August through March 1955.

043274 *X Cam.* Two brighter-than-8 maxima in mid-January and mid-June, on either side of a shallow 12th magnitude minimum, followed by a faint 8.7 maximum early in November.

043738 *R Cae.* A faint max. the last of February 1954 is followed by one more than a magnitude brighter the last of March 1955.

044349 *R Pic.* Too irregular to predict during the last two years.

050848 *S Pic.* A very wide, bright (7th mag.) maximum the last of June 1954 follows a normal 8th magnitude maximum.

053005a *T Ori.* Erratic, possibly rapid changes of a magnitude or more have been noted by several observers.

053326 *RR Tau.* Very active during the year, at times seems to vary from 11 to 13, with a period of about 40 days.

053337 *RU Aur.* Did not rise above 11½ mag. at time of last maximum in the latter part of December. At the previous max. in the middle of September 1953, it reached 8.8 magnitude.

054319 *SU Tau.* Back to normal magnitude between 9.5 and 10 by the last of April, after a minimum of a little over 100 days, during which the star varied between 12 and 13th magnitude.

054629 *R Col.* A faint 10½ magnitude max. early in February 1955 follows a 9½ magnitude one in the latter part of February 1954, which in turn followed a bright 8½ magnitude maximum the last of March 1953.

054974 *V Cam.* More observations are needed for this circumpolar variable. A max. near the middle of November is apparently about 50 days later than predicted.

063462 *RR Pic, Nova 1925.* Constant at 11.3 for several years.

070122a *R Gem.* A normal 7.1 magnitude max. was observed near the predicted time of the last of March 1954. It was followed by a bright minimum of 12.4, which occurred about 30 days earlier than the predicted time. The recent max. near the first of March was 6.8 mag., and nearly 40 days earlier than predicted.

072609 *U Mon.* A very good star for binocular observations. It is an RV Tauri-type variable, which varies from about 6 to 7½, with a period of 92.3 days. Max. II — Max. I = 46 days, according to P. Ahnert.

080835 *CP Pup, Nova 1942.* Constant at 11th magnitude for several years.

082405 *RT Hya.* Too irregular to make predictions.

094836 *U LMi.* Very irregular during 1954.

095814 *RY Leo.* Range decreased from more than two magnitudes in 1952 and 1953 to about one magnitude in 1954 and early 1955.

101058a *Z Car.* Faint 11½ magnitude maximum the last of March 1954. Previous max. was 10th mag.

105259 *AG Car.* Star was constant at 8.2 from 1950 until March 1954, when it rose suddenly to 7th mag., and started rapid fluctuations between 7th and 8th magnitudes.

111561 *RY Car.* Faint max. in July, below 12th magnitude. Previous max. was 11th magnitude.

114858 *AD Cen.* Nearly constant at 8.2 magnitude.

115158 *Z UMa.* Last five epochs have had secondary max. near time of minimum.

121418 *R Crv.* A 7th magnitude maximum in the latter part of March 1954 followed by an 8½ mag. one in the middle of February 1955.

123160 *T UMa.* A faint maximum, 8½, in late May 1954, followed by one a magnitude brighter in mid-February 1955.

123459 *RS UMa.* A bright max., (mag. 8.6) the last of May, followed by a faint one (mag. 10.2) in early February 1955.

145971 *S Aps.* A very shallow minimum, less than one magnitude, was observed between the middle of November and the last of February 1955.

152714 *RU Lib.* A faint max., about 9.0, observed in the middle of June.

154428 *R CrB.* No activity during the year.

160519 *W Sco.* More observations are needed for this variable. It does not get much brighter than 12, so a large instrument is necessary.

162119 *U Her.* A faint maximum, 8.6 magnitude, was observed during the latter part of March 1954.

163360 *TX Dra.* Since the end of 1953, TX has had fairly regular maxima about 70 to 90 days apart. It has a small range—less than one magnitude. Sometimes the star varies irregularly, and at other times it will be constant for long intervals.

164844 *RS Sco.* A normal max. of 6.8 magnitude observed in mid-February was followed by a very faint one, about 8.2 mag., in the latter part of December.

174162 *W Pav.* A 10th magnitude max. the first of January was followed by a bright one, about 8.2, in early October.

174406 *RS Oph, Nova 1901 and 1933.* During the year, the observations scatter between 11th and 12th magnitudes, possibly due to small, rapid fluctuations.

180445 *DQ Her, Nova 1934.* Remains nearly constant around 14th magnitude.

184300 *V603 Aql, Nova 1918.* Nearly constant at about 11½ magnitude.

194632 *Chi Cyg.* A very narrow max., mag. 5.6, was observed early in March 1954. The increasing branch of the curve was especially steep, and the width of the curve at 9th magnitude was about 100 days, barely half of the normal width at that magnitude.

201520 *V Sge.* Extremely rapid changes of one magnitude or more have been suspected by several observers.

203501 *AE Aqr.* A good deal of minor activity was observed during the year, but no very bright flares were seen.

212030 *S Mic.* Both max. observed in 1954, last of March and last of October, were fainter than 10th magnitude. The preceding one in mid-August 1953, was 8½ mag.

224552 *DK Lac, Nova 1950.* Now between 13th and 14th magnitudes.

235659 *WZ Cas.* A little more activity was observed during the year, with a 7th magnitude maximum in May, and an 8th magnitude minimum early in November.

Observations received during March and April 1955: In March 63 observers contributed 5,119 observations, and in April 52 submitted 5,983—a total of 11,102 for the two months.

Observer	March		April		Observer	March		April	
	No. Var.	No. Ests.	No. Var.	No. Ests.		No. Var.	No. Ests.	No. Var.	No. Ests.
Abbey, L. B., Jr.	7	8	..	..	Maran, S. P.	27	28	19	19
Adams, R. M.	49	143	44	148	McPherson, C. A.	12	12	..	..
Alvarez, H.	..	..	3	4	Mebius, W. G.	5	8	5	13
Ancarani, M.	7	17	..	..	Miller, W. A.	21	31	15	18
Anderer, J. A.	3	3	..		Montague, A. C.	15	15	23	34
Anderson, C. E.	68	110	69	112	Moore, P.	..	..	2	24
Aronowitz, C.	144	275	142	342	Morgan, F. P.	8	17	9	37
Barber, W. F.	1	6	..	..	Mount, A. W.	6	13	..	..
Behar, A.	6	15	..	..	Ohta, Akira	..	..	19	103
Beidler, H. B.	29	50	30	85	Oravec, E. G.	173	509	169	535
Bicknell, R. H.	..	..	11	75	Parker, P. O.	11	12	29	31
Boutell, H. G.	5	15	8	28	Pearcy, R. E.	7	7	7	7
Breckinridge, J.	3	3	2	2	Peltier, L. C.	20	119	35	143
Charles, D. F.	8	8	7	7	Peters, J. G.	..	..	1	1
Cragg, T. A.	140	151	155	158	Pohl, E.	18	82	..	..
Crouse, L.	1	1	..	..	Ricker, C. L.	..	..	2	4
*Darsenius, G. O.	51	236	20	190	Rizzo, P. V.	27	29	31	48
Diedrich, DeL.	3	3	8	10	Rosebrugh, D. W.	15	53	15	62
Diedrich, G.	5	6	12	20	Royer, R.	19	26	12	14
Elias, D. P.	92	291	82	379	Saffadi, R.	3	4	..	..
Eliasoff, A. L.	20	29	11	21	Schultz, G. W.	24	40	33	72
Erpenstein, O. M.	12	13	2	2	Segers, C. L.	..	..	21	66
Estremadoyro, V. A.	4	4	8	8	Semos, E. B.	6	16	..	..
Fernald, C. F.	145	203	106	140	Silverstein, Anne	2	2	..	..
Ford, C. B.	141	141	113	117	Skaritka, P.	209	399	206	614
Gaustad, J. E.	..	..	16	16	Solomon, L.	100	284	158	480
Goldenblatt, P. P.	49	125	41	116	Stupp, Allan	..	..	8	28
Goodsell, J. G.	4	4	3	3	Sullivan, W. H.	2	4	..	..
Hartmann, F.	139	160	121	121	Taboada, D.	125	202	97	170
Hein, G.	194	407	211	511	Thomas, H. D.	8	8	..	..
Johnsson, R G.	4	4	..	..	Thomas, M. A.	3	11	..	..
Kastin, H.	11	11	58	156	Walsh, J. F.	4	7	..	..
Kelly, F. J.	11	11	10	13	Weitzenhoffer, K.	16	23	..	..
Kimball, M.	26	71	33	73	Womelsdorff, R. W.	2	10	..	..
Knowles, J. H.	8	20	..	..	Wyckoff, J.	21	29	17	31
de Kock, R. P.	119	554	130	561	Yamada, T.	..	..	9	11
Lacchini, G. B.	14	21	..	..					

*Plus 10 minutes Lalande 21258A (WX UMa)
28 minutes BD+55° 1823 2 hours 21 minutes Kruger 60B (DO Cep)

Nova Search Report for March and April 1955 (From the new Chairman): After years and years of mailing Nova observations to A.A.V.S.O. Headquarters in Cambridge, it is with some inertia that observers are being re-trained to mail them to George Diedrich at the new Nova Headquarters, 653 Weller Road, Elyria, Ohio. Hence this report is undoubtedly incomplete, and should be considered as interim until we are properly squared away. Nova Search reports were contributed for March and April by (at least) the following five observers:

DELORNE DIEDRICH: Areas 40, 94; GEORGE DIEDRICH: Dome, 56; LOUIS RICK: Dome, 18, 65; BEAUFORT RAGLAND: 56, 71; WILLIAM SULLIVAN: 21, 22, 33–38, 50–56, 68–72, 82–84, 91–94, 101–103.

METEOR NEWS

By Peter M. Millman, *National Research Council, Ottawa*

Photographic Meteor Spectra (Appendix 3)

As a continuation of the comprehensive listing of all photographic meteor spectra (see the Journal, vol. 46, p. 121, 1952; vol.47, p. 217, 1953; vol. 48, p. 225, 1954) those spectra which were secured prior to the end of 1954 and which were not listed before, are tabulated below in Appendix 3. This brings the world list to a total of 148 and includes, to Dec. 31, 1954, all recognizable meteor spectra of which I have knowledge. I would greatly appreciate having my attention called to any that have been missed in this listing.

LIST OF PHOTOGRAPHIC METEOR SPECTRA (APPENDIX 3)

No.	Date			G.C.T.			Shower	Location (observatory)	Ref.
	y	m	d	h	m	s			
141	1952	12	10	6	31	00		Dona Ana, N.M. (H.C.O.)	
142	1954	3	9	5	36	03		Meanook, Alta. (D.O.)	
143		6	30	6	10	20		Soledad, N.M. (H.C.O.)	
144		8	8	6	00	*		Meanook, Alta. (D.O.)	
145		8	8	7	35	*		Meanook, Alta. (D.O.)	
146		8	13	6	29	55	P	Metcalfe Rd., Ont. (D.O.)	
147		12	14	4	18	*	G	Meanook, Alta. (D.O.)	
148		12	21	10	30	*		Casaday's Ranch, Calif. (U.S.C.)	

References

26. Russell, J. A., *Meteorites*, vol. 1, p. 103, 1953. (Spectrum 120)
27. Cook, A. F., and Millman, P. M., *Ap. J.*, vol. 121, p. 250, 1955. (Spectrum 110)

As before the table includes the identifying serial number of the spectrum, the date and time of the meteor in Universal Time (an asterisk stands for mid-exposure when the meteor was not visually observed), the shower with which the meteor can be identified, the location of the observing station and, in brackets, the institution responsible for the programme.

Spectrum 141 and Spectrum 143 were secured in connection with the Harvard Observatory systematic programme of meteor photography, carried out until recently near Las Cruces, N.M. Spectrum 148 was photographed by Mr. Clark Harris, President of the Los Angeles Astronomical Society. This programme was organized by Professor John A. Russell, Head of the Department of Astronomy at the University of

Southern California. In recent years Prof. Russell's group has been very active in securing meteor spectra and this is the tenth photographed by them since 1948.

The remaining 5 spectra in Appendix 3 were secured on programmes carried out by the Dominion Observatory. During 1954 the writer was assisted by Professor J. E. Kennedy of the University of New Brunswick in the Ottawa meteor photography. Photography at the western meteor observatories at Meanook and Newbrook, Alta. was carried out by Mr. A. A. Griffin, Mr. J. M. Grant and Mr. Dennis Corness during 1954. Up to the end of the year this programme was under the general direction of the writer. However, commencing with January 1955, when I transferred to the National Research Council, the programme at the Meanook and Newbrook Meteor Observatories has been in charge of Dr. J. L. Locke, new Chief of the Stellar Physics Division at the Dominion Observatory, assisted by Dr. Ian Halliday, who has recently been appointed to the Division and is specializing in the photographic study of meteors. In Appendix 3 I have also listed the new references in this field which have appeared since the publication of Appendix 2.

Orionid and Geminid Observations at Montreal

Miss I. K. Williamson, Chairman of the Meteor Section in the Montreal Centre of the Society, has forwarded the observations which were made during last winter at the new observatory of the Centre located near the McGill stadium. The co-ordinates are—lat. 45° 30′ 42″ N., long. 73° 34′ 53″ W. Montreal has always been one of our most active observing Centres and it is nice to know that they now have a permanent headquarters belonging to the Society. The members are to be congratulated on their enthusiasm and industry, which has made this observatory possible.

Orionid observations were carried out on the night of Oct. 22/23, 1954. From 10 p.m. to around midnight the sky was generally clear. After midnight clouds gradually filled in from the north-west and observations were discontinued at 12.40 a.m. Those taking part in this programme are listed below:

E. E. Bridgen, Miss Anna Mary Burditt, Brian Cockhill, F. DeKinder, D. E. Douglas, C. M. Good, Miss Louisa Good, A. Grenier, G. H. Hall, Miss Rosemary Jamieson, Brahm Muhlstock, Paul S. Scott, David Smith, R. Venor, Miss Arden Taylor, Miss I. K. Williamson, Miss Lillian Wilson, Mrs. M. I. Yane, David Zackon, Mrs. D. Zorgo.

The numbers of meteors seen, the mean rates and the magnitude distributions are given in the accompanying tables. The rates for Montreal are somewhat lower than those recorded in Regina over roughly the same period on the following night (see Journal, vol. 49, no. 3).

NUMBERS OF METEORS OBSERVED

E.S.T.	Oct. 22/23, 1954 (10 observers) Orionids	Non-shower	Dec. 11/12, 1954 (6 observers) Geminids	Non-shower
22.00–22.20	6	1		
–22.40	4	0		
–23.00	3	1		
–23.20	6	1	4	1
–23.40	9	0	1	0
–00.00	4	2	7	1
–00.20	3	0	3	0
–00.40			6	0
00.40–01.00			3	2
Totals	35	5	24	4
Mean hourly rate, six obervers	13	2	12	2

MAGNITUDE DISTRIBUTIONS

Date \ Mag.	0	1	2	3	4	5	Total	Mean Mag.
Oct. 22/23 (O)	1	5	14	9	5	1	35	2.43
(N)		1	1	2	1		5	2.06
Dec. 11/12 (G)	1	4	8	7	4		24	2.38
(N)			1	1	2		4	3.25

The moon was just past the full for the Geminid shower in 1954 and not many programmes were planned since good photography was more or less out of the question. I was particularly pleased to have the Montreal visual record of the Geminids, observed under good moonlight conditions. Those taking part in the observations are listed below:

E. E. Bridgen, F. DeKinder, C. M. Good, Miss Rosemary Jamieson, Andrew Laur, Brahm Muhlstock, Miss Arden Taylor, R. Venor, Miss I. K. Williamson, Mrs. M. I. Yane, David Zackon, Mrs. D. Zorgo.

The numbers observed, standard rates and magnitude distributions are given in the tables. A system of rotating observers was used on both programmes so that the numbers of observers listed in the table correspond to those actually watching the sky all the time. A timekeeper and a recorder were also an duty throughout the periods of observation.

A PROVISIONAL SUPPLEMENTARY LIST OF METEOR SHOWERS

In the JOURNAL last year, vol. 48, p. 193, 1954, I published a provisional list of twenty meteor showers. At the time this was prepared I made up

a supplementary list of an additional twenty showers, many of which seemed less certain, especially as to radiant position and time of maximum. In view of the fact that the first list has apparently been of use to a number of meteor observers I am venturing to publish the supplementary list here. All the remarks which I made relative to the first list apply here also. I should particularly warn the readers of these notes to regard the values given in the table as tentative only and subject to future revision. Also it is fairly certain that many showers equal to or better than those listed have been omitted from the table through lack of observational data. The description of the various columns given with the first list applies here as well.

PROVISIONAL SUPPLEMETARY LIST OF METEOR SHOWERS

Shower	At Shower Maximum				Daily Motion of Radiant		Equivalent Total Hourly Number of Meteors for a Single Observer at Shower Maximum	Normal Duration (days)	Observed Geocentric Velocity (km./sec.)
	$\lambda \odot$	Mean Evening Date	Radiant (1950) α	δ	α	δ			
Cygnids	296°	Jan. 16	295°	+55°					
Bootids	350	Mar. 10	220	+10					
Hydraids	4	Mar. 24	185	−25					
Virginids	6	Mar. 26	190	0				15	31
α Virginids	20	Apr. 9	210	−10					
Piscids (May)	49	May 9	25	+25					
54 Perseids	93	June 24	70	+35			15 (daytime)	15	
α Ori, λ Gem, ν Gem	110	July 12	100	+15			40 (daytime)	10	
β Cap, σ Cap	(113)	(July 15)	310	−15	+96′	+ 8′	30 (daytime)	5	
θ Aurigids	122	July 25	85	+40				10	
							15 (daytime)	10	
α Capricornids	(124)	(July 27)	305	−10	+46	+ 7			
δ Capricornids	(125)	(July 28)	325	−15				10	
α Piscis Australids	(130)	(August 2)	345	−30	+60	+ 14		15	
ζ Aquarids	(132)	(August 4)	335	0				10	
Cygnid-Cepheids	143	August 15	310	+55				15	
								10	
κ Cygnids	147	August 19	290	+55					
Piscids (Sept.)	169	Sept. 11	0	+ 5				15	26
Perseids (Sept.)	171	Sept. 13	55	+40					
Bielids II	251	Dec. 3	25	+45				10	
Velaids	277	Dec. 28	150	−50				5	

NOTES AND QUERIES

Jupiter is a Radio Source

Although radio noise has been detected from the centre of the galaxy, from the sun, from a few external galaxies and other discrete sources, radio signals had not been attributed to a planet until this year. Drs. B. F. Burke and K. L. Franklin of the Carnegie Institution of Washington, reported on this in April at the American Astronomical Society meeting at Princeton, N.J. These scientists were using a radio-telescope operating at a frequency of 22 megacycles/sec. (corresponding to a wave-length of 13.5 metres); the telescope was used as a transit instrument, and had an elliptical beam 1.6 by 2.4 degrees of arc.

When working on a sky-survey project at declination 22°N. they found a strong source of radio noise in the direction of Gemini. This was finally traced to the planet Jupiter, for the noise occurred only during the six minutes that Jupiter was crossing the beam of the antenna, and changes in the direction of the source over the course of months corresponded exactly to changes in the position of Jupiter among the stars. However, Jupiter's noise occurred on only nine of the thirty transits observed, and was of an irregular nature.

The cause of the radio bursts from Jupiter is unknown. If the noise is caused by electrical discharges in the planet's atmosphere (like terrestrial lightning) the effect would have to be on a tremendously larger scale than on earth to account for the intensity of the observed noise.

R. J. N.

Jupiter's Satellites

The four bright satellites of Jupiter are of continual interest to the observer with a small telescope. These satellites, in their motion about their parent planet, are eclipsed by the shadow cast by Jupiter, occulted by the planet itself, and can be seen in transit across Jupiter's disk. Even the shadows of the satellites can be glimpsed as they cross the face of the planet. It is unusual, however, to happen to observe one satellite transit another. On the evening of February 19, 1955 two observers, one in New York and one in Uniontown, Pa., saw Europa, satellite II, transit directly across Ganymede, satellite III, at 9:22 p.m.

E.S.T. Transits of one satellite by another are not predicted, but the other phenomena of the bright satellites appear in the OBSERVER'S HANDBOOK.

Besides the four bright satellites, Jupiter has eight other moons which are extremely faint. One of these faint, distant satellites, number VIII, has been lost for long intervals of time since its discovery in 1908. It was last seen in 1941. On the average this satellite is about 15 million miles from Jupiter; this, combined with its small size (estimated to be less than forty miles), results in the satellite undergoing complex perturbations caused by the sun. To compute the ephemeris of the satellite by an ordinary desk calculating machine is much too laborious to be attempted. And thus the little satellite was lost. Recently however, Dr. Paul Herget of Cincinnati Observatory, assisted by Dr. John Mauchly, has used UNIVAC, Remington Rand's electronic computer, to calculate the positions of Jupited VIII for every ten days from 1940 to 1980. The predicted positions were sent to Dr. Seth B. Nicholson of Mount Wilson and Palomar Observatories. On January 25, 1955 Jupiter VIII was found within one minute of arc of its predicted place on that date. Dr. Herget reports that as a result of the computed ephemeris it should be possible the satellite should be able to be photographed each time Jupiter is at opposition.

R. J. N.

NOTES FROM THE NATIONAL OFFICE

From the Winnipeg Centre, Miss Arlyne Rosenblat and Mr. G. Marcy Wiseman (Secretary-Treasurer) have come to the David Dunlap Observatory for the summer as student assistants.

Toronto Centre will again be an exhibitor at the Canadian National Exhibition August 26–September 10 in Toronto. According to Mr. F. L. Troyer, Secretary, the Telescope Makers Group will demonstrate a number of instruments. The moon, Saturn, and double stars will be viewed, weather permitting.

Members of your National Council had the pleasure of welcoming Dr. R. M. Petrie, National President of the Society, Director of the Dominion Astrophysical Observatory at Victoria, B.C., on June 8th on the occasion of his first visit to us as council chairman.

Our Editor, Dr. C. A. Chant, was congratulated on his ninetieth birthday on May 31 (which was also the twentieth anniversary of the dedication of the David Dunlap Observatory) by the National Council and the staff of the Observatory. Ten days earlier, on May 20, one of our early

members and former National President, Mr. J. R. Collins, was similarly congratulated on his ninetieth birthday.

Centre secretaries and treasurers are asked to refer to minutes of the National Council meetings November 8, 1954, and February 15, 1955, respecting "distribution of publications" and "quarterly reports". Please remind your members that 1956 dues are payable prior to January 1, 1956. (If you failed to receive your copies of the minutes, another copy will be sent from the National office upon request.)

All members and friends of the Society who come to Toronto are cordially invited to visit the national office and library at 13 Ross Street. The telephone number is WAlnut 3–3784.

D. C. W.

Comparison of Temperatures in the Northern and Southern Hemispheres

Letter to the Editors:

It is generally assumed that the sun (and of course other stars as well) radiates diffusely and equally into space in all directions. The radiation reaching the planets is assumed therefore to obey the inverse square law. On this basis, temperatures have been deduced for planets in the solar system other than the earth, ranging from the very hot, capable of melting metals, to cold capable of condensing elements normally gaseous on earth.

It is also generally accepted that the earth rotates around the sun in an ellipse, being 3 per cent. closer to the sun in December than it is in June. This would require, on the basis of the inverse square law, that the radiation reaching the earth should be approximately 6 per cent. less in June than in December. On this basis, according to Gamow, (*Biography of the Earth*, p. 150), "the mean temperatures of northern summers must be 4 to 5°C. (7 to 9°F.) lower, and the mean temperatures of northern winters 4 to 5 degrees higher, than the corresponding values for the Southern Hemisphere."

However, an assessment of mean temperatures of many individual locations at equal latitudes north and south, or at the equator, does not show the differences that Gamow indicates. The actual differences in temperature do not appear to exceed, at most, a third the values he suggests.

The supposition might be made, in explanation of this discrepancy, that the sun does not radiate diffusely in all directions but that its radiation is attracted to, or concentrated by, the fields of the planets,

or of the combined fields of the planets and their individual moons. The radiation of the sun, whatever its primary nature, might be assumed thus to be "beamed" at the planets. If this is so, it would of course change our concept of the temperature of the other planets, and of the sun itself. Such "beams" would be entirely invisible to us in space, but might transitorily increase the illumination of any object that happened to pass through them.

On this basis, changes in radiation reaching the planets might be expected when two of them are in opposition. Richardson reports (*Exploring Mars*, p. 139) a series of observations indicating that the blue haze of Mars clears at or about the date of opposition and cites the suggestion of E. P. Martz, Jr. that "the earth's magnetic field might have an effect on radiation from the sun, such as to cause a variation in the solar radiation falling on Mars . . ." For many years, C. G. Abbot and his collaborators have been recording the amount of solar radiation reaching the earth. In a prodigious analysis, Abbot has noted a number of unexplained periodicities in this phenomenon (*Smithsonian Misc. Coll.* vol. 117, no. 10, 1952). Of course, the amount of solar radiation reaching the earth's surface must result from a composite of many factors. However, I have compared three dates of opposition of Mars and the earth (at or near which Richardson reports clearing of the Martian haze) with the chart of solar radiation published by Abbot. In each case (May 1937, July 1939, October 1941) an increase in solar radiation occurred at or near this time.

The attractive effect of a large gravitational field for a beam of light was predicted by Einstein and the existence of this phenomenon has repeatedly been confirmed by observation of starlight passing the sun during an eclipse. May not this phenomenon operate on a more magnified scale within the solar system itself?

MORTON S. BISKIND

At the request of the Editors the Meteorological Service of Canada supplies the following information.

Letter to the Editors:

Although the earth's outer atmosphere receives more radiation in December than in June, it does not follow that the solar radiation reaching the earth's surface is necessarily higher for the southern hemisphere summer than for the northern hemisphere summer. The depletion depends on water vapour content, clouds and haze and is therefore greater in the southern hemisphere which has the larger oceanic area.

The precise magnitudes of the surface solar fluxes cannot be stated, however, since adequate radiation data, especially over oceans, are lacking.

Before discussing seasonal temperatures, one should bear in mind that the mean temperature of the northern hemisphere is about 3–3.5°F. warmer than that of the southern hemisphere. This arises in part from the greater land cover of the northern hemisphere and in part from its warmer oceans. The net drift of warm surface water at the equator is northward, and the northern oceans are partly protected from arctic ice and polar waters by land barriers.

A final factor to consider is the effect of land cover on annual temperature range. The large land masses of the northern hemisphere lead to a much greater annual range for that hemisphere than is observed in the dominantly maritime southern hemisphere. All these considerations are required in order to explain the observed mean temperatures quoted below, in degrees Fahrenheit:

	Yearly	*January*	*July*
	°	°	°
Northern hemisphere	59.3	46.5	72.3
Southern hemisphere	56.0	62.7	49.5
Whole earth	57.7	54.6	60.8

When individual latitudes are compared, the northern hemisphere winter is warmer than that of the southern from 70–90° and from the equator to 30°; the northern hemisphere summer is warmer at all latitudes than that in the southern hemisphere. For individual stations, the effects of topography, continentality, air-mass and radiation regimes would all have to be considered.

ANDREW THOMSON, *Controller*

MEETINGS OF THE SOCIETY

AT EDMONTON

Report of the Observers Group

The year 1954 has been a good one for Edmonton Centre observers. In our ever-increasing programme of astronomical activities, we have now observers in Calgary and Wanham, Alberta. Contact has recently been made with the Regina Astronomical Society and it is hoped that a series of observational programmes can be worked out with them in the coming years. Here in Edmonton, the observational committee consists of four divisions each having one chairman.

I. *Atmospheric Phenomena* under Earl Milton:

Aurora Borealis: A total of 386 reports were received covering 194 displays of which 184 were observed in Edmonton. 12 observers participated in this programme.

Meteors: During the year three major showers were observed. First, the Lyrids, on April 20–21 at which time only 3 meteors were seen because of poor seeing. The Persieds were observed on August 11–12 and August 13–14, and 65 meteors were plotted. Both evenings were clouded out before midnight. On December 13–14 and December 14–15 the Geminids were observed with a total of 52 being recorded. Several fireball reports were received, one of which was seen on December 19–20 having a magnitude of −13 and is believed to have fallen fairly close to Edmonton.

Solar and Lunar Haloes: 28 reports were received covering 14 solar and 10 lunar haloes.

II. *Solar and Lunar Observations* under Franklin Loehde:

Sun-spots: A total of 264 observations were made of the sun during the year, using two 6-inch reflectors and an 8-inch reflector. During this time 68 groups and 256 spots were seen.

Faculae: From the beginning of September to the end of the year 89 observations were made and from these 46 groups of faculae were noted over a total of 38 days.

Eclipses: On January 18–19 a total eclipse of the moon was observed by five observers. Clouds and cold hindered the usefulness of the work. On June 29–30 a partial view of the solar eclipse was seen by ten observers. Three other members of the centre ventured east for a view of the total phase, but only one of the three was successful.

Lunar Observations: Observations were carried out with drawings of various lunar features like Schroders Valley, the "Lunar Bridge," and the crater Haze being made. Observation of 10 lunar occultations were attempted, but all were clouded out.

III. *Planetary and Comet Observations* under Arthur Dalton:

Planets: Mars, Jupiter, and Saturn were studied. Among the results were good views of Syrtis Major and the polar cap of Mars, numerous belts and four of Jupiter's satellites, and Cassini's division of the rings of Saturn along with four of its satellites.

Comets: Observations of Pons-Brookes comet during the spring perihelion were prevented by cloudy skies.

IV. *Photographic Observations* under Ian McLennan:

Moving pictures and still photographs were taken both telescopically and otherwise of the June 30 solar eclipse. Also photographed during the year were numerous star trails, auroral formations, and lunar photographs. All are being collected and placed in an album which will be placed in the centre's library for the use of all the members.

Also observed were some of the objects in Messier's Catalogue of 109 Clusters and Nebulae. Three observers found between 30 and 50 of these objects by the end of the year. It is hoped that in the coming year the observational activities of this centre will continue to increase as in the last two years.

EARL MILTON

February 11, 1954—The meeting was called to order at 8.20.

The Handbook talk was given by Dr. Campbell.

Observing Group news: Poor aurora period of two months. No sun-spots visible. Thin cloud for total eclipse of moon, colours were interesting but no good timing. Twelve Gemini meteors observed in 1 hour.

The main paper was given by K. B. Newbound, whose subject was "Spectroscopy in Astronomy". There are many ways in which the development of astronomy has been helped. What is spectroscopy? It is the study of how light arises and what story it can tell us. The role of spectral lines, and the energy levels associated with their emission were explained. These can also be seen in absorption. The photosphere of a star produces a continuous spectrum, which is selectively absorbed in the reversing layer, further out and cooler. Identifying the lines gives information about the chemical elements present and the temperature of the reversing layer.

Doppler effect studies are widely used, red shift means recession. Rotation of two limbs of the sun can be measured this way. Change in shift over long time intervals, a means of detecting and measuring double or triple systems. Pulsating stars are also studied by these methods. Expanding shells of super-novae can be studied.

Observation of certain "forbidden" lines gives an indication of low density of gas in the region observed.

Peculiar combined absorption and emission pattern from B emission stars can be interpreted by special stellar structure and relative rotation, with Doppler effects playing a large part.

There were 20 members and visitors present.

E. H. GOWAN, *Secretary*

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